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North American Council on Fishery Investigations

PROCEEDINGS 1934–1936

No. 3

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PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1939

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During the past triennial period there has been little change in the constitution and work of the council. The new fisheries research vessel of France, *Président Théodore Tissier*, crossed the Atlantic in 1934. This permitted the 21st meeting of the council to be held on board the vessel, while in Halifax harbour, that is, technically on French soil. That meeting was also outstanding as one with a very full representation of fishery investigators from France. Newfoundland has actively continued her program of fisheries investigation throughout the period, and has sent to each meeting of the council comprehensive accounts of the results obtained, even when she was unable to send a representative.

To facilitate the work of the council, five standing committees have been appointed, covering the subjects "Fishery statistics," "Ground fish," "Pelagic fish,", "Shore fish," and "Hydrography." To provide time for meetings of these committees as well as for the sessions of the council, the length of the annual meeting has been extended to three days.

The council has continued its co-operation with the European "International Council for the Exploration of the Sea." Both the chairman and the secretary attended the meeting of the latter council at Copenhagen in May, 1935, and Dr. Johan Hjort, of Norway, a member of that council, attended the 23rd meeting of the North American Council at New York in September, 1936.

At the meeting of the council in September, 1934, a communication from the European council was read proposing common study by the two bodies of parallel fluctuations in the fish stocks on both sides of the North Atlantic. Dr. LeDanois, who is a member of both councils, strongly supported the proposal. As a result, each council has appointed reporters to deal with the important food fishes that come into consideration,—cod, herring, haddock, salmon, halibut and blue-fish. All available data on the abundance of the various year-classes of each fish are being collected and compared.

* With the exception of the part for Canada, these Proceedings were prepared during the winter of 1936-1937 and the statements made are, therefore, not necessarily valid as of later dates.

REGULAR MEETINGS OF THE COUNCIL

No	Place	Date	Members and Advisers present			
			Canada	France	Newfoundland	United States
21	Halifax, N.S. (on board *Président Théodore Tissier*)	Sept. 19–21, 1931.	W. A. Found A. G. Huntsman J. P. McMurrich A. B. Needler [2] A. E. Calder [2] D. B. Finn [2] H. B. Hachey [2] F. R. Hayes [2] A. H. Leim [2] R. A. McKenzie [2] A. W. H. Needler [2] H. F. S. Paisley [2] D. H. Sutherland [2] V. D. Vladykov [2] A. H. Whitman [2] S. A. Beatty [2] R. G. MacKay [2]	Ed. LeDanois M. L. Beaugé G. Belloc [2] P. Desbrosses [2] E. Priol [2] J. Cochin [2] P. DeMorsier [2] M. Weill [2]	H. Thompson	H. B. Bigelow [1] E. Higgins C. E. Jackson (vice Bell) W. C. Herrington [2] C. Iselin [2] O. E. Sette [2]
22	Washington, D.C., U.S.A.	Sept. 17–19, 1935.	W. A. Found A. G. Huntsman H. B. Hachey [2] A. H. Leim [2] R. A. McKenzie [2] A. W. H. Needler [2] H. F. S. Paisley [2]			F. T. Bell H. B. Bigelow [1] E. Higgins E. W. Bailey [2] W. C. Herrington [2] C. Iselin [2] R. H. Fiedler [2] R. A. Nesbit [2] W. C. Schroeder [2] O. E. Sette [2] J. R. Webster [2] Lt. Commdr. Richmond [2] A. F. Feliciano [2]
23	New York, U.S.A	Sept. 23–25, 1936.	W. A Found A. G. Huntsman J. P. McMurrich H. B. Hachey [2] A. H. Leim [2] R. A. McKenzie [2] A. W. H. Needler [2]			F. T. Bell H. B. Bigelow [1] E. Higgins R. H. Fiedler [2] W. C. Herrington [2] W. C. Schroeder [2] O. E. Sette [2] J. R. Webster

[1] Chairman. [2] Technical advisers.

CANADA

The Biological Board, which investigates Canadian fishery problems was under the chairmanship of Professor A. T. Cameron during this three-year period. Investigations on the Atlantic coast were carried out largely by members of the staff of the Atlantic Biological Station, consisting of A. H. Leim, director; H. B. Hachey, assistant hydrographer; R. A. McKenzie, V. D. Vladykov, and H. C. White, scientific assistants, and W. H. Johnson and R. E. S. Homans, research assistants. Also A. G. Huntsman, consulting director of the board, was concerned with the investigations.

COD

(Mr. McKenzie)

The movements of the cod were explored by *tagging experiments* as follows. In 1934, in the Halifax area, in the vicinity of Egg island, about 500 were tagged in 50 fathoms of water, and 800 in about 25 fathoms. Of these 24·3 per cent were recaptured by 1936. Those in the shoaler water show less extended movement, a large proportion moving out to a little deeper water during the winter and directly back inshore the next spring. Those in the deeper water move as far as cape Sable to the southwest and Canso to the northeast during

the season and out to the Western banks during the winter. In the next season some may go eastwards as far as Cape Breton or even Newfoundland. In 1935, 550 cod were tagged at various points from Halifax to Quereau bank and Ingonish, Cape Breton, and with similar results, there being little inshore movement from the outer banks and limited coast-wise movement for the fish near shore. In 1936 there was tagging not only off Halifax, and on Quereau bank but also in the Orphan-Bradelle Bank region of the southern part of the gulf of St. Lawrence with results showing some movement from the outer banks into the gulf.

More or less *separate populations* of cod have been found from studying the number of vertebrae in the backbone. Autumn-spawning cod, occurring from Halifax to St. Margaret bay, have the smallest number (average: 51·6) and a winter school found on the Western banks has the largest number (average: 53·3). The others are intermediate and occupy the following areas: Bay of Fundy to cape Sable; Browns bank to Roseway bank with neighbouring shore; shore of Lunenburg and Halifax counties with Sambro, Emerald and Sable Island banks; Guysborough County shore and outer Cape Breton with Middle and Quereau banks; Canadian shore of gulf of St. Lawrence; and deeper waters off that shore. The number of vertebrae increases from warm to cold water and from shore to deep water.

In tank experiments the *effect of temperature* on cod has been observed. Large cod cannot survive as high temperatures as can small cod. The rate of respiration of the cod rises and falls regularly with the temperature, and old fish have a slower rate than young fish. The amount of food consumed by the fish increases with rise in temperature up to about 50° F. but decreases above that temperature. At low temperatures they do not take as large pieces of food as at high temperatures.

HADDOCK

(Dr. Vladykov and Mr. Homans)

Tagging experiments in 1935 gave few returns. There were in all 1,897 fish tagged at St. Margaret bay, at Ingonish, Cape Breton, and on the Western bank. The principal movement shown was eastward (or into the gulf of St. Lawrence) in each case, from St. Margaret bay to Cape Breton, from Western bank to Sable island, and from Ingonish to Prince Edward Island.

Quite *separate populations,* to be distinguished by the average number of vertebrae on the backbone, occur off the New England coast, around the Canadian coast (chiefly Nova Scotia), and in Newfoundland waters. The population around Nova Scotia, which has the largest average number of vertebrae is more or less distinctly divided into smaller populations, western Nova Scotia, central Nova Scotia, eastern Nova Scotia, and Sable Island and Quereau banks, with the number of vertebrae increasing in that order.

The *food* of the haddock has been determined from examination of the stomach contents of many thousands of fish. The largest proportion to have food is from August to October and the lowest from February to May, the reverse of the condition for the sexual organs, which enlarge for the spawning

time, which is from March to May. On the Western bank, the principal food is fish, almost wholly sand eels (*Ammodytes*). Inshore haddock eat chiefly echinoderms and mollusks, those in the bay of Fundy having large numbers of mollusks (chiefly *Yoldia*), and those outside Nova Scotia and in the gulf of St. Lawrence containing little besides brittle stars (Ophiurids).

SALMON

(Dr. Huntsman and Mr. White)

In the bay of Fundy, the salmon are chiefly found in spring and summer where most drift bottles go ashore (wind-driven surface current is an important factor) and where there is water of low salinity extending out from a river mouth, as for the Saint John, and such determines whether they are taken by weirs on the shore or by drift nets offshore. The *distribution* of the salmon *in the sea* roughly corresponds with their previous distribution as young in the river or rivers, those from the uppermost tributaries of a river or of an arm of the sea being nearest the mouth of the river or of the arm of the sea.

Tagging experiments with salmon in the sea as taken by trap nets on the west coast of Cape Breton near the Margaree river (100 tagged in 1935 and 160 in 1936) showed movement coastwise in both directions and on and off shore, rather than to any river. The more extended coastwise movement was 5 miles to the southwest and 56 miles to the northeast in 1935, but 120 miles to the southwest (also out of the gulf of St. Lawrence through the gut of Canso to Chedabucto bay) and only 18 miles to the northeast in 1936. The salmon, whether tagged or untagged, were to be found in the river as shown by angling only following more or less pronounced freshets (rise and fall in discharge of river water), and not in relation to operation of the nets. The latter affect the angling merely by reducing the total number of salmon, of which they take perhaps a fifth.

The *transplantation* of 25,000 fry from Restigouche salmon into the East branch of the Apple river at the head of the bay of Fundy in 1932, gave 3,252 smolts, which were trapped and marked when descending to the sea in the spring of 1934. In 1935, as grilse, about 18 of them were taken by poachers in the river estuary, and 92 ascended the East branch and six the West branch of the river, the latter occurring only near spawning time. In 1936, 19 that had spawned as grilse the previous year ascended the East branch and one the West branch; in addition, four that had remained in the sea two years ascended the East branch and one the West branch. This behaviour as to time spent in the sea and size at return agrees with that of the local salmon, from which they could not be distinguished, and not with that of their Restigouche parents. In returning to fresh water, they entered only the stream in which they had been reared, until near spawning time when no selection was apparent.

Destruction of the young in the Margaree river was found to be due in large part to birds, chiefly kingfishers and mergansers, whose elimination would probably greatly increase the number of smolts descending to the sea.

HERRING

(Dr. Huntsman and Mr. Johnson)

There was further confirmation of the view that the small "sardine" herring of the Passamaquoddy region are largely determined in their distribution by the hydrodynamic forces set up by fresh-water discharge from the rivers, a heavy freshet in the fall, as in September of 1933, giving heavy fishing at so-called "spring" weirs, which ordinarily fish well only during the spring freshets.

Observations with a hydro-periscope on the small herring in weirs in the sea and results of the operation of gill nets at various depths showed that while the herring were near the surface when the light intensity was low, they were some distance, but not more than 10 feet, from the surface in strong sunlight, and that the larger they were the greater the distance they kept from the surface.

HYDROLOGY

(Mr. Hachey)

Coastal surface temperatures were followed at as many as fourteen points, with observations twice daily, but the work was more or less curtailed in 1936. The records show that the comparatively well mixed water of the bay of Fundy changes in temperature gradually and regularly with the season, but that highly stratified waters such as those on the outer coast of Nova Scotia, are apt to show sharp and erratic changes (from 65° to 43° F. within a few days at Sambro island in September, 1933) from upwelling of deeper water accompanying atmospheric disturbances. In a district, such as the north shore of the gulf of St. Lawrence, between regions with very cold and very warm surface water, the mean temperature for a summer month may vary greatly from year to year, as a result of large scale movements of the water, as of Labrador water through the strait of Belle Isle.

The waters of the *Scotian Shelf*, outside Nova Scotia, continued to be intensively studied. The *sharp and erratic changes* in the character of the inshore bottom water in summer, that have such a marked effect on the coastal fisheries, are seen as closely related to steep gradients in atmospheric pressure, measured by the barometer. With the pressure high on the coast and low out in the ocean the warm surface water "piles," that is becomes deeper, and the cold, salter water below moves away. When the pressure gradient is reversed, the warm, surface water leaves the coast to be replaced by the colder water from below. There are rather pronounced *yearly variations* in temperature and salinity. In the summer of 1934 the water was on the whole warmer and salter than in the two previous years, as a result of the movement of ocean water inward from beyond the outer banks, which brought in September even into Halifax harbour large numbers of an oceanic, brown jellyfish (*Pelagia noctiluca*). In 1935 a large volume of cold water (below 41° F.) flooded the shelf, coming from the eastward (probably of Labrador or Newfoundland origin) and persisted throughout the season, making that year a cold one. The summer of 1936 was intermediate in temperature, thus differing from those of the two preceding

years, but in detail there was less movement than usual from the east in early spring of cold water at intermediate depths, while there was considerable increase in this cold water from May to August, so that it was finally in larger amount (though not very low in temperature) than in the two previous years.

PLANKTON

(Dr. Huntsman and Mr. Johnson)

Deep water planktonic forms such as *Calanus* and Euphausiids, known as "red feed" and "shrimp" respectively to the herring fishermen of the bay of Fundy, are produced in large quantities in the gulf of Maine and carried in deep water movements into the bay of Fundy. The mechanism by which these are made available near the surface, not only for fishes like the herring and pollock, but also for many birds, such as gulls and terns, was revealed by investigating the effect of a sudden, heavy rainfall (five inches during a single night) over the drainage basin of Passamaquoddy bay in September of 1933. The deep, narrow, irregular passages near the mouth of the bay in which there is very effective mixing of the water, were at the end of a long dry period, practically cleared of the deep-water forms commonly seen near the surface. Then, between nine and twelve days after the rain, as the freshwater worked out of the bay, these forms suddenly appeared in the passages in great abundance.

Various kinds of copepods ("red feed") that are eaten by the herring and other fishes have different and changing distributions in depth with the varying light conditions throughout the day, and these determine their availability to the herring for food. It is found that the *changes* in light intensity, as contrasted with the actual intensity at any one time, not only have a pronounced effect in altering the distribution of the copepods as a whole, but also produce different effects in different species and even within the one species, depending upon sex, etc.

UNITED STATES

Fishery investigations of the United States Bureau of Fisheries are carried on by a number of biologists in its Division of Scientific Inquiry, the chief of which is Elmer Higgins. Within the division are section heads in charge of scientific work in the several natural geographical divisions of the country. Those along the northern border of the United States are: Frederick A. Davidson, in charge Pacific fisheries investigations; John Van Oosten, in charge Great Lakes investigations; and Oscar E. Sette, in charge North Atlantic investigations, also director of the United States Fisheries Biological Station, Woods Hole, Mass. In the North Atlantic section William C. Herrington is in charge of haddock investigations and Oscar E. Sette of mackerel investigations. William C. Schroeder, of the Woods Hole Oceanographic Institution, is studying the cod from materials collected prior to his separation from the Bureau of Fisheries in 1932. Attached to the North Atlantic staff as assistants are John R. Webster, William C. Neville, Frank E. Firth, and Henry M. Bearse.

General fishery statistics are collected by the Division of Fishery Industries and published as separate bulletins as well as in the annual reports of the Division of Fishery Industries and in synoptic form in the annual report of the United States Commissioner of Fisheries. In addition, detailed statistics on particular species are collected by the biological staff of the North Atlantic section.

On the Atlantic coast research in physical and biological phases of oceanography, related to fisheries biology, is also carried on by the Woods Hole Oceanographic Institution, director of which is Henry B. Bigelow. The institution has a permanent staff of 18 members; grants about 14 fellowships annually; and provides facilities for approximately 14 independent investigators at its laboratory. It operates the research ship *Atlantis* and a 40-foot motor boat, *Asterias*.

MACKEREL INVESTIGATIONS

The mackerel investigations begun by O. E. Sette in 1925 continued under his direction during the last three years. Observations on relative importance of year classes, their variations in geographical and seasonal distribution, their rates of decline in abundance, and the effects of these on the success of the commercial fishery have provided a basis for reasonably reliable annual predictions of the abundance of the mackerel particularly during the first half of each season.

Of particular interest in the field of marine fishery research have been the following results of the last three years of study:—

1. The numbers of mackerel surviving to commercial size differ greatly as between year classes. In descending order of numerical richness the year classes are provisionally ranked as follows: 1933, 1931, 1923, 1928, 1934, 1930, 1921, 1922, 1929, 1924, 1932, 1927, 1925, and 1926.

2. There appear to be two types of year classes in the mackerel population. The "persistent type," as exemplified by the year classes of 1923, 1930, 1931, and 1933, remains in the population sampled by the United States fleet for a number of years, whereas the transitory type, as exemplified by the classes of 1921, 1927, 1928, and 1929, disappears rapidly so that hardly any fish remain in this population more than three years after reaching commercial size. The persistent type appears to be of more southerly distribution, not occurring in samples taken north of the Gulf of Maine; while the transitory type appears to be more northerly in distribution, particularly after reaching maturity.

Although investigations of conditions on the spawning grounds were terminated in 1932 when the research vessel *Albatross II* was removed from service, study of the materials collected prior to that date continued during the last three years. Of particular interest is the 1932 survey which was carried out with methods improved sufficiently to receive quantitative treatment. That season is now known to have contributed but few recruits to the commercial stock and therefore must have been one of high "infant mortality." A commonly-accepted theory of the cause of such year-class failures has been that the newly-hatched young do not survive the yolk-sac stage, but the data of 1932 do not indicate an appreciably higher rate of mortality at this supposedly critical

point than during subsequent stages up to the size of 10 millimeters. If this is confirmed by examination of other years' data, it will have important bearing on further search for the causes of failures in year classes—a phenomenon occurring not only in the mackerel but in many important food fishes, one that has been perplexing to the students of fisheries biology and one that has not yet been satisfactorily explained in the case of any marine species.

HADDOCK

The investigation of the haddock populations exploited by the New England fishing fleet has continued on the general lines outlined in previous reports. Primary emphasis has been placed on the statistical and biological analysis of the extent and cause of the fluctuations in the populations of the grounds fished by the New England fleet, that is, South channel, Georges bank, and the banks lying off the Nova Scotian coast.

During the past three years the total haddock landings at the principal New England ports increased from the 1932 low of 120,000,000 pounds to 157,000,000 in 1935, then again decreased in 1936. The 1935 increase resulted primarily from extensive catches made on the banks lying off the Nova Scotian coast. Although the catch during 1934 to 1936 was considerably above the preceding three years, it was much below the 1928 to 1930 level. The 1936 decline resulted partly from the decreased catch on the Nova Scotian banks and partly from the transfer of fishing activity to redfish.

The fluctuations in abundance of haddock as distinguished from fluctuations in landings have been determined by means of the "catch-per-day's fishing" computed from detailed catch records of three groups of trawlers. On Georges bank and South channel, which have supplied 40 per cent of the haddock catch during the past three years (compared to 80 per cent during the previous ten years), the catch-per-day increased from about 9,700 pounds in 1933 to 14,000 pounds in 1936. On the Nova Scotian banks, which have supplied about 56 per cent of the landings, the daily catch declined from about 17,700 pounds in 1933 to 14,000 in 1936.

Biostatistical evidence indicates that the improvement in the Georges bank catch rate was due to a good 1931 year class, a fair 1932 class, and an excellent 1933 class, combined with a much reduced fishing intensity; while on the Nova Scotian banks the decline from the 1933 peak was due to the partial or complete failure of the 1930, 1931, and 1932 classes in this region, combined with a greatly increased fishing intensity.

Evidence from length frequencies and growth rates continued to indicate that there is no extensive intermigration between Georges bank and the Nova Scotian banks, although there may be a limited interchange among the older fish. The very marked difference in the size of the two-year-old haddock on Georges and Browns banks in the spring of 1936 (averaging 35 to 36 centimeters on Georges and 23 centimeters on Browns) showed that there had been no intermixing of young fish of this age.

Knowledge of the geographic and size distribution of young haddock was greatly increased by data collected on *Atlantis* trawling trips made in the spring

of 1935 and 1936. All of Georges bank and South channel and the southern part of Browns bank were covered on these trips. One-year-old haddock were found in greatest numbers along the eastern and southeastern part of Georges bank in depths of 50 to 60 fathoms, and along the southern part of Browns bank to even greater depths. Very limited numbers were found in some of the other areas sampled. Two-year-old haddock were found in eastern and central Georges in depths from 30 to 50 fathoms. Older fish were found mainly along the northern, northeastern, and north central part of the bank. There did not appear to be any very definite correlation with temperature but the range was small as most of the bank was covered with water between 5° and 6° C. One-year-old fish were most numerous to the south and east of the older classes and in slightly colder water. Quantitative comparisons based on catch-per-hour's towing indicated that the 1935 class was about three times as abundant as that of 1934. Among one-year-old haddock males and females were about equally represented while among the older fish the males ranged from 70 per cent in South channel to 42 per cent in central and southern Georges. The percentage of males for all areas combined (except Browns bank) was I-group, 49 per cent; II-group and older, 55 per cent.

Some progress has been made in introducing large-meshed nets into the commercial fishery in order to reduce the destruction of small haddock. Several operators have been using this gear on some of their boats and late in 1936 the New England trawlers' organization agreed to use cod-ends with a $4\frac{3}{4}$-inch mesh on all of their boats for a six-months' trial beginning in the spring of 1937.

COD

Cod investigations during the triennium 1934 to 1936 were confined to the analysis of data obtained from tagging experiments of previous years (1924 to 1932) and from temperature-growth studies of fish kept in aquaria. This latter experiment has not as yet been concluded.

Returns of tagged individuals confirmed the formerly-reported conclusions as to migrations. A comparison of disk and belly-tagged cod indicates a greater permanence of the latter type of tag, second and third year returns of belly tags being markedly superior to externally-attached disk tags, though returns from both types were very low after the first year.

Examination of scales collected during tagging operations from 1923 to 1931 indicate that there is a decided difference in the number of circuli in the first growth zone of cod living in different localities. It appears that these circulus counts are reasonably constant in a given locality, from year to year, and that an employment of this technique of scale reading will furnish important information regarding migrations for correlation with marking experiments.

FISHERY STATISTICS

Among the statistics collected by the Bureau of Fisheries, two series are pertinent to the work of the North American Council. One consists of comprehensive statistics on the number of persons engaged, the number and size of craft, and the number of units of gear employed, in the fisheries, and the

quantity and value of the catch of all commercial fisheries in particular geographical sections. The other is the monthly landings of vessels at the principal New England ports classified according to gear and fishing area. The comprehensive series on New England was collected for the year 1935, the years 1934 and 1936 being omitted for lack of funds. The port series was continued during the three-year period, and beginning with 1936, the classification of catch according to areas was revised to correspond with the system proposed by the Committee on Statistics of the North American Council at its meeting of 1935. Principal changes from the former classification consist of the grouping of contiguous small grounds and subdivision of the large grounds such as Georges Bank, which under the old system was carried as one item and under the new system appears in six subdivisions (Eastern Side South channel, Northern Edge of Georges, Northeast Peak of Georges, Central Georges, Southeast Georges, and Southwest Georges), an arrangement which will make the statistics more useful for biological studies.

HYDROLOGICAL INVESTIGATIONS

SUMMARY OF PROGRESS

During no other period has such a great number of important papers been published dealing with the problems of oceanic circulation. Concerning the movements of the offshore waters, great progress has been made both through theoretical and descriptive studies. This advance is particularly striking in the results obtained by the *Meteor* expedition. In fact, it can now be said that in both the North Atlantic and the South Atlantic the first exploratory stage of physical oceanography has definitely been passed. Unfortunately our advance in understanding of the coastal circulation has not kept pace, in spite of the fact that the examination of coastal conditions has proceeded at an increased rate.

The rather striking advance which has recently been made in problems of oceanic circulation has not greatly benefited biological investigators whose main interest has always been in coastal regions. It is natural, therefore, that those who are working on fisheries problems should begin to feel that physical studies are becoming of doubtful practical value. The physical oceanographer often finds himself unable to be of material assistance to his biological associates. It may be clarifying to all concerned if the difficulties that are met with in studying shallow water movements are briefly reviewed in the light of the recent advances in physical oceanography.

There are three chief factors which produce the movements in the waters over the continental shelf. Two of these play a very minor role in the ocean basins. As is well known, the dominant set in coastal currents results largely from the effects of land drainage. Coastal waters are nearly always fresher and therefore lighter than offshore waters and this contrast in density maintains a current system which under the most simple conditions will flow with its greatest strength along the edge of the continental shelf. Associated with this density current is a lateral transfer, outward at the surface and inward along the bottom. In this way the coastal waters do not continually decrease in salinity. However,

they are nearly always enough fresher than offshore waters so that in spite of the temperature distribution, some density gradient remains. Obviously, the seasonal thermal cycle and the variations in land drainage produce changes in the strength of the permanent coastal currents.

If it were necessary to consider only these forces the coastal circulation could be worked out on the basis of comparatively simple hydrological observations similar to the methods that have proved so helpful in deep water. Unfortunately, in coastal studies the second factor, namely the tidal currents, cannot be neglected. Not only do the tides distort the isopycnal surfaces thus rendering dynamic studies most difficult, but they cause differences in the rate of mixing from region to region. However, it seems that even though complicated by the tidal currents, the pattern of coastal circulation would be fairly well known were it not for the third factor, namely the frictional effect of the wind at the surface.

In the open ocean the energy which is absorbed from the wind can be regarded as being accumulative in effect. In other words, the minor irregularities of the wind system can be to some extent neglected because the field is so large. But on the continental shelf north of the tropics every slight change in the wind may alter the currents produced both by the density contrasts and by the tides. Until the magnitude of the wind effect has been definitely proved, coastal circulation cannot be solved in manner really helpful to biological investigations. Thus it is a mistake to imagine that a network of temperature and salinity observations, secured during the course of a biological survey, can be depended on to demonstrate the current system. Until more work has been done on the wind effect, our understanding of coastal circulation will remain in its present unsatisfactory state.

INVESTIGATIONS

During the period 1934 to 1936 the Bureau of Fisheries has continued to receive daily sea water temperatures from between forty and fifty lightships and lighthouses along the Atlantic coast. Its other hydrological activities have been confined to the taking of temperatures in connection with the haddock trawling cruises performed by *Atlantis,* and summarized below (p.).

Further results have been forthcoming from the hydrographic data collected in connection with mackerel spawning surveys prior to 1932 in the form of a paper by H. B. Bigelow and Mary Sears, *"Studies of the waters on the continental shelf, Cape Cod to Chesapeake Bay." II Salinity. Papers in physical oceanography and meteorology published by Massachusetts Institute of Technology and Woods Hole Oceanographic Institution, Vol. IV, No. 1, Cambridge, Mass., July, 1935.* The plankton collections are being studied by Mary Sears.

The hydrological investigations of the Woods Hole Oceanographic Institution on *Atlantis* during the years 1934 to 1936 can be summarized as follows:—

1934—(*a*) Eight cruises to the Gulf of Maine, January to September.
(*b*) Survey of the Caribbean Sea and the Florida Straits, February and March.

1935—(*a*) Survey of the Gulf of Mexico, January to April.

(*b*) Supplementary chemical and hydrological stations from the Gulf of Maine, August and November.

(*c*) Sections south and east of the Grand Banks, September.

1936—(*a*) Three surveys of the eastern slope water area, March, June, and September.

(*b*) Two additional cruises to the Gulf of Maine, May and August.

(*c*) A study of internal waves south of the Gulf Stream, July.

During this three-year period the *Atlantis* completed 41 cruises. Of these 17 were devoted to various biological investigations, 4 to geological studies, and 20 to examining the circulation and the physical properties of the water. A total of 816 stations was occupied for serial observations of temperature, salinity, and oxygen. The corrected observations are being published annually in the *Bulletin Hydrographique* of the *Conseil permanent International pour l'Exploration de la Mer.*

The hydrological observations of the International Ice Patrol and Ice Observation Service carried out by the U. S. Coast Guard during the seasons 1934 to 1936 can be summarized as follows:—

1934—April 17-June 29.—4 dynamic surveys of the critical area off the "tail" of the Grand Banks.

July and August.—2 sections across the continental shelf northeast of Newfoundland and a section across the Labrador Sea from southern Labrador to Cape Farewell.

1935—March 28-June 10.—3 current surveys totalling 167 stations in the area immediately south and east of the Grand Banks.

July 10-August 23.—110 stations from the Labrador Deep and the region of the supposed Newfoundland ridge.

1936—April and May.—Current surveys from the critical ice area.

July and August.—Repetition of the section across the Labrador Sea.

During the last three years frequent surface temperature charts have been constructed and these continue to furnish important clues concerning the details of the current pattern. In addition to the routine observations, great advances have been made in following from a quantitative point of view the fluctuations from year to year in the strength of the currents. Also, the observations are now being studied in the light of recent advances in physical oceanographic theory. In particular, considerable progress has been made in examining the large scale subsurface mixing processes.

Besides the report of these investigations published each year in the *U. S. Coast Guard Bulletins,* a comprehensive paper *(Bulletin No. 19, Part II)* on the hydrology of the Labrador Sea and the eastern Grand Banks region has recently been sent to the printer and should appear during the summer of 1937.

WOODS HOLE OCEANOGRAPHIC INSTITUTION

Reports on the activities of the Woods Hole Oceanographic Institution have been regularly presented to the Council at its meetings.

1. *The Gulf of Maine.*—The periodic cruises begun in 1933 were continued intensively during 1934. Surveys of the chemical and hydrological conditions have now been carried out for almost every month of the year. The extensive data thereby secured permits the study by modern methods of important oceanographic problems not particular to this comparatively well-known area. Not only is it possible to follow closely the seasonal changes in the rate of circulation in a typical coastal region, but also the vertical and horizontal transport of essential chemicals can be studied in great detail. The observations are being also used to examine the changes in turbulence from region to region and at different depths.

Since general plankton collections were secured at the same time, the whole cycle of biological activity can be correlated with the physical environment. The observations are being studied from the standpoint of circulation by Dr. E. E. Watson and from a physiological point of view by Dr. A. C. Redfield.

2. *The Caribbean and the Gulf of Mexico.*—In co-operation with the Bingham Oceanographic foundation the winter surveys of this region have been extended so that a close network of stations is now available covering the whole area. The extensive data are being worked up under the direction of Professor A. E. Parr.

3. *The eastern slope water area.*—During 1936 three surveys were completed of the waters lying between the edge of the continental shelf and the Gulf Stream, from off Georges Bank eastward to the Grand Banks. It is expected that the observations will not only clarify the complex surface eddies along the northern edge of the Gulf Stream, but also show the extent to which this area is influenced by the inflow, both at the surface and at mid-depths, of water from northern North Atlantic. The data will also be used to examine in detail the contact between the coastal and offshore waters and the factors causing fluctuations in bottom temperature along the edge of the continental shelf.

4. *Current measurement and submarine waves.*—From time to time the *Atlantis* has attempted the difficult problem of current meter observations. Experience has been gained in the technique of anchoring the ship in deep water. A frame for securing current readings just over the bottom has been built and used successfully. However, it must be admitted that current readings at mid-depths cannot yet easily be made with the accuracy desirable.

During July, 1936, a study was made of internal waves in the area between Bermuda and the Gulf Stream. A total of 44 series of observations for temperature, salinity and oxygen was repeated as rapidly as possible in order to observe the subsurface changes occurring at a single station.

5. *Cruises devoted primarily to biological investigations.*—These can be summarized as follows:—

(*a*) In co-operation with the U. S. Bureau of Fisheries a net-work of bottom trawling stations on Georges bank was occupied on five different occasions.

(*b*) Five cruises were also devoted to studying the vertical distribution of the larger zooplankton in deep water. The closing mechanism for two-meter closing nets has been further perfected in the course of this work.

(*c*) The cycle of bacteria has been observed during the course of the year at typical localities in the Gulf of Maine.

(*d*) Two cruises were given over to further studies of the problems connected with the penetration of light in the sea.

6. *Submarine geology.*—A large number of bottom samples has been secured, both by dredge and sounding tube, from the submarine canyons along the southern edge of Georges bank and also off Delaware. The new explosive sounding tube designed by Dr. Piggot has been tried out with great success. One cruise was devoted to measuring the thickness of the unconsolidated sediments over the continental shelf by seismic methods.

7. *Publications*—

(*a*) The chemical and hydrological observations secured by the *Atlantis* have appeared annually in the *Bulletin Hydrographique* published by the *Conseil Permanent International pour l'Exploitation de la Mer.*

(*b*) Approximately 67 shorter papers devoted to a wide range of subjects have appeared in the three volumes of *Collected Reprints* that have been prepared during this period.

(*c*) In the series entitled *Papers in Physical Oceanography and Meteorology* published by *Massachusetts Institute of Technology and Woods Hole Oceanographic Institution*, the following longer papers have been published:—

Vol. III, No. 1. H. R. Seiwell: The distribution of oxygen in the western basin of the North Atlantic, 1934.

No. 3. C.-G. Rossby and R. B. Montgomery: The layer of frictional influence in wind and ocean currents, 1935.

No. 4. H. R. Seiwell: The cycle of phophorus in the western basin of the North Atlantic. I. Phosphate phosphorus, 1935.

Vol. IV, No. 1. Henry B. Bigelow and Mary Sears: Studies of the waters on the continental shelf, Cape Cod to Chesapeake Bay, II. Salinity, 1935.

No. 3. C.-G. Rossby and R. B. Montgomery: On the momentum transfer at the sea surface, 1936.

No. 4. C. O'D. Iselin: A study of the circulation of the western North Atlantic, 1936.

Vol. V. No. 1. C.-G. Rossby: Dynamics of steady ocean currents in the light of experimental fluid mechanics, 1936.

NEWFOUNDLAND

HYDROGRAPHY

During the spring of 1934 warm Atlantic water spread in a northeasterly direction over the Grand banks and in that section of the area there occurred the warmest conditions noted during the four year period of study; minimum temperatures occurred chiefly at a depth of 50-75 metres, the level of minimum temperature having risen consistently since 1932. However, on the Southwest Coast region conditions were colder than usual, the area being flooded to a considerable depth with cold continental water, probably the result of extremely cold conditions in the previous winter. This body of water resisted to a large extent the advance of warm Atlantic water, even flooding the outer Nova Scotia bank area in spring. Indications of the impending warm Atlantic influx of 1934 were had in the fall of 1933, warmer temperatures at the depth of 100 metres having begun to show it. Furthermore, from a comparison of the salinities in the deeper water layers for the four years, it was noticeable that these were greatest during 1934.

Lower salinities were, however, noticed in the fall of 1934 in the Labrador area, indicating the possibility of renewed intensity in the Arctic current the following season. This increase actually continued in 1935, though noted for the most part in the Labrador and northeastern section, including the straits of Belle Isle. Thus sub-surface waters in this area were in spring colder than at any time in recent years and less saline. On the Grand Bank section conditions differed markedly from those of the previous year, the warm Atlantic influx being much more restricted; its influence was felt largely in the region of the gulf of St. Lawrence, and round the north of Newfoundland. This warm water did not, however, mix with the cold mass of water which was still present off the southwest coast from the previous year, and the fishery off that section of the coast suffered accordingly. On the whole, however, temperatures in the eastern area fell to more normal figures, during the year, whilst the south and west inshore region failed to register the desirable increase, although the offshore waters showed a considerable rise in temperature. Salinities also fell during the year, especially in the northeast section, where in the upper layers the lowest salinities for the five year period were recorded. This effect was less evident in the south and in the west because apparent only later in the year.

No comparative figures are available for 1936.

PLANKTON INVESTIGATIONS

The results of the 1934 and 1935 plankton work bear out the assumption made on results of the work of 1931-33 and referred to in the Proceedings of the Council (No. 2) that the average volume of plankton forms, obtained by centrifuging the organisms retained in a standard haul of the Hjort silk net, is proportional to the strength of the Arctic current.

The following table gives the figures from spring, 1933, to fall, 1936.

Year	(Average volume in ccs. per average haul)		Notes	
	Spring	Fall	Spring	Fall
1933	23·6	7·5	*Maximum reached.* Arctic species prevail.	Sharp decrease of Arctic forms. Increase of warm water forms.
1934	6·6	3·7	*Further decrease.* (Ctenophores plentiful).	*Decrease* to point of scarcity.
1935	7·0	6·5	*Moderate increase.* (Medusae interfered).	*Increase* to average amount.

The marked influx of Arctic water in 1932-33 with the consequent maximum of plankton in spring, 1933, was followed by a sharp decrease (Atlantic water increase). By the fall of 1934 the plankton had decreased to the point of scarcity. By the fall of 1935, accompanying renewed strength of the Arctic current, the volume of plankton had again assumed almost normal proportions.

The enumeration of the cold water species *Oikopleura vanhöffeni* continued to give a reliable indication of water conditions, as shown by the following figures.

	Spring	Fall
1931	....	27
1932	635	124
1933	1,342	26
1934	327	101
1935	385	23

The first signs of the return to cold conditions after the 1934 influx of warm Atlantic water were noted in the fall of 1934, when, off Labrador and in White bay, water salinities became lower, and *Oikopleura vanhöffeni* increased in numbers for the first time since the spring of 1932.

It is now proved that this species occurs only in water derived directly from the Arctic current and therefore larger numbers naturally occur in spring. This fact should be borne in mind in reference to the figure for spring, 1935. The cruise that year was a few weeks later than usual and therefore the figure probably underestimates the quantity of the species. Further, it appears possible to forecast the relative intensity of the Arctic current for the spring by studying the relative number of *O. vanhöffeni* in the previous fall. It would appear established, therefore, that the variation in the number of *O. vanhöffeni*, a characteristically cold water species, affords a finer indication of existing and probable future conditions, than the variation in the total volume of all species of plankton. The accompanying graphs show the relationship clearly. Figure 1 shows the general trend plainly, but Figure 2 giving the quantities of *O. vanhöffeni* accentuates the effect.

The unusual occurrence in spring of the warm water species *Sagitta serratodentata* at some of the more southerly stations in 1934 was an additional indication of the pronounced diminution of the Arctic current and consequent influx of Gulf Stream water, thus bearing out the general argument. Furthermore, an analysis which has been made of the genus *Ceratium* shows that the

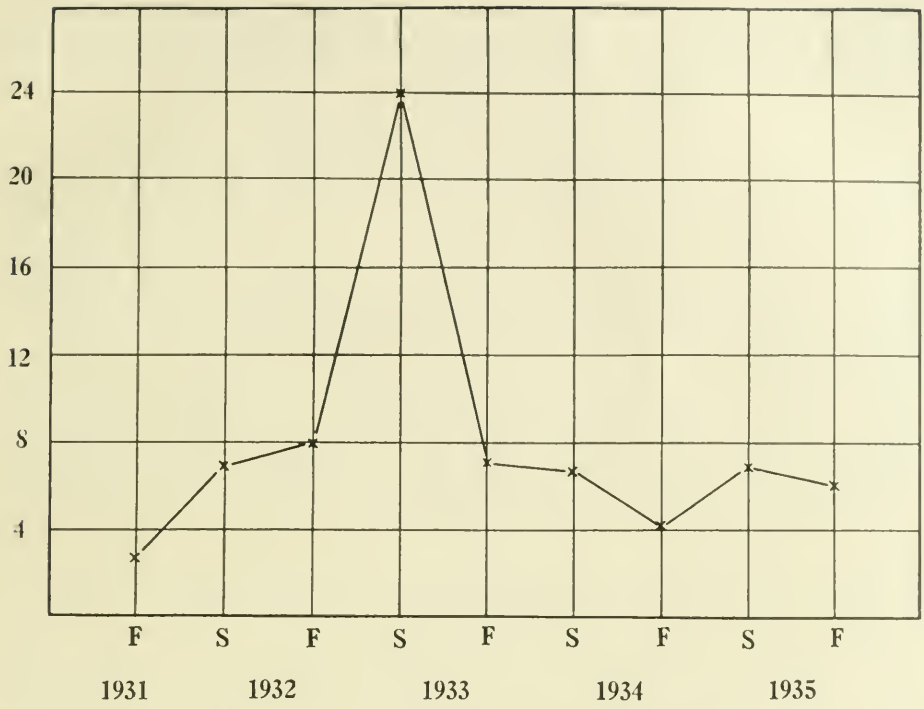

FIG. 1.—Showing average volume (in ccs) of plankton per 100m. haul of vertical Hjort net.

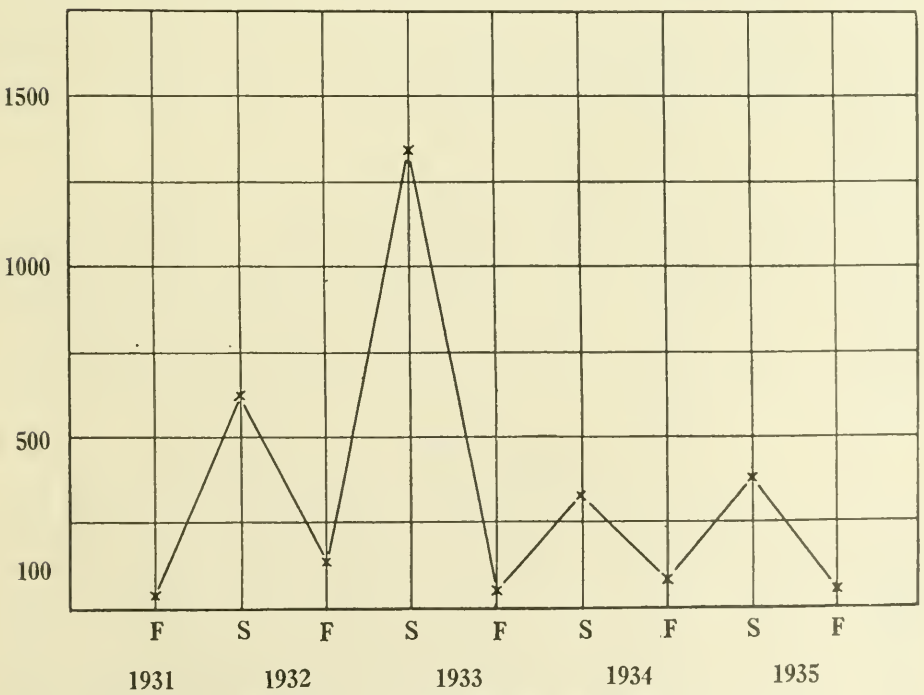

FIG. 2.—Showing average number of *Oikopleura vanhöffeni* per 100m. haul of vertical Hjort net.

six species commonly present in the area form a perfect series in their reaction to Arctic and Atlantic water conditions and lead to the same conclusions as those derived from the important *Copelata* group.

COD INVESTIGATIONS

During commercial cruises undertaken by the S.T. *Cape Agulhas* in 1934 and 1935 varying hydrographic conditions were encountered. However, as a result of guiding the activities of the vessel in accordance with the temperature of the water, catches, successful as to quantity and quality, were obtained. It was thus definitely shown that the occurrence and size of cod depended upon the temperature.

In March, 1934, the fishing on Sable Island bank proved unproductive because this area was flooded with cold water from the St. Lawrence; the temperature from surface to bottom was 0°C. Accordingly the trawler removed to Grand bank where the bottom temperatures of three trips varied from -½°C to 9½°C, averaging 5·7°C, 4·8°C, and 2·5°C respectively. It was found that between 3° and 7° large catches of small and medium sized cod were obtained. By shifting the position in the second cruise more to the northeast, the size of the bulk of the catch was raised from a range of 53 to 70 cms. (voyage 1) to a range of 66-80 cms. (voyage 2). This conclusion would seem to apply only to the months of March and April because in May, 1934, even in a low range of temperature fewer large cod were available. In March and April the cod were feeding, whereas in May they had probably moved to the spawning grounds.

It had been noted in 1933 that large cod remained on the grounds until early in June. This 1933 observation probably represents the more normal occurrence, since 1934 was marked by an unusually large influx of warm water felt on the banks earlier in the season and therefore causing an earlier migration of the large cod.

1. *Inshore*

As shown by statistics of four Bay Bulls traps over a period of four years (1931-34) the results of the inshore fishery are extremely variable. In 1932 and 1933, when Arctic water was plentiful, the fishing was best both as regards size of catch and size of fish. In 1934 the large fish were obtained by hook and line. That is, it was necessary to fish at greater depth to reach the colder water which these fish inhabited.

The drop in size of fish caught in 1934 may not have been due entirely to the higher temperatures at Bay Bulls in that year. A contributing factor may have been the departure from the shore of the previously prominent 1924 brood which seemed to have been replaced by the young 1927, 1928 and 1929 year classes. Thus, in 1935 the cod caught inshore were still small but showed a year's growth over 1934 measurements. The same year classes are likely to predominate for a year or two and therefore increasing size of fish is to be expected. The supply of cod depends on both factors, namely, (1) suitable water conditions, and (2) the existence of a series of year classes of satisfactory proportions.

Another feature of the 1934 season was this: Whereas along most parts of the shore and especially in the southeast the fishery was a failure, farther north in Fogo district the fishery was excellent. This observation is in accordance with the general conclusions as to the effect of temperature. The large influx of warm water of that year extended its influence to the southeast coast producing unfavourable water conditions in that region. Two hundred miles further north conditions were what they should have been for a successful fishery in the southeast region.

2. *Racial Groups*

Data gathered from the reading of cod scales indicate that the various racial groups do not intermingle in the adolescent stages. Thus, the amount of the first year's growth as indicated by the number of sclerites in the first year, diminishes as we move in a direction from south-west to north-east. For example, the average number of first year sclerites of fish captured on the Grand banks was twelve to fifteen, whereas off Labrador the number averaged eight. Work has been done on vertebral counts and will be continued.

3. *Tagging Experiments*

During the years 1933-35, a total of 8,336 cod were tagged and up to December, 1936, 780 of these have been recaptured. The numbers are made up as follows:—

—	Tagged	Recaptured	Per cent recaptured
1933	273	28	10
1934	3,022	383	13
1935	5,041	369	7
	8,336	780	.....

Of the fish tagged on the banks only 1·8 per cent have been reported recaptured, whereas in some regions inshore the returns have been as high as 20 per cent to 25 per cent. Many of the returns have come from fish tagged earlier in the one season. This gives some indication of the intensity of the inshore fishery in regions where traps are used.

Returns show that within the first year of release, the cod do not travel far, but recaptures during the second year of freedom indicate that considerable migrations may be undertaken. However, about three-quarters of the returns still come from within a radius of 100 miles.

HADDOCK INVESTIGATIONS

From the study of the distribution of sizes and the relative frequency of occurrence of year classes during 1934, it was predicted that haddock would again be plentiful (on Grand bank where they chiefly occur) in 1935. This was amply shown by the results of commercial and investigational fishing. Thus if the results of the four commercial voyages of S.T. *Cape Agulhas* in spring are compared with those of the previous year, when haddock were considered to be

plentiful, an actual improvement in the average number of quintals (of approx. 400 pounds) taken per two hours' haul is observed:—

Year	−1° to +1°	1° to 3°	3° to 4°	4° to 5°	5° to 6°	6° to 7°	7° to 9°
1934.....	....	4·0	4·5	7·0	8·5	9·5	6
1935.....	0·5 [49]	4·0 [196]	8·2 [9]	17·4 [18]	19·7 [3]	17·7 [3]	1 [1]

(The water temperatures at which hauls were made are given above in degrees Centigrade, and the number of hauls giving the 1935 results are given below in brackets; it will be seen from the latter that the great bulk of the hauls were made in cold water between 1° and 3°, as cod, not haddock, were being sought. Highest catches of haddock were, however, obtained between 4° and 7° as in the previous year). Results from 1936 observations tend to substantiate the above figures.

As has been shown elsewhere (e.g. North sea, George's bank, etc.), the haddock fishery fluctuates greatly, this being caused chiefly by the varying degree of success of reproduction from year to year. From Newfoundland work it would appear that 1924-25, 1927-29, and 1933-34 were productive years. The 1927-29 broods formed the bulk of the 1934 and 1935 hauls, though in the latter year the 1927 brood showed a notable decrease in numbers. These fish would then have been in their ninth year and it is probable that on Grand bank haddock of this age cease to influence the catch in a dominant manner. Accordingly, as the 1933-34 broods reach the requisite size of 40 centimetres and appear in the commercial catches, they may be expected to replace the 1928 and 1929 broods. The prospect is, therefore, for good fishing on Grand bank for a further period of years at least, with a decrease in the average size of fish caught.

SALMON INVESTIGATIONS

Sufficient material has been obtained to complete the broad classification of salmon and a separate publication in contemplated which will serve as a background for the more specialized investigations now necessary for individual rivers.

The more important preliminary conclusions may be summarized as follows:—

(1) The rate of regeneration of stock decreases progressively in a northerly direction. The sea-going smolt stage is attained at three years of age in the most southerly rivers, increasing to four years in the mid-eastern region, and to five years some way up the Labrador coast. The observed ages on the Labrador coast (maximum eight years) are the highest recorded smolt ages for Atlantic salmon.

(2) Owing to the foregoing considerations, measures of conservation would have to be contemplated if there arises any considerable development of fishing activity towards the north. Furthermore, in northerly regions the short season of possible interchange between river and sea results in a high catch of spent salmon.

(3) The occurrence of grilse in proportionally large numbers in a certain year has been found to be an indication that in the succeeding year salmon of the same year of birth, but which have spent two years at sea, will tend to be plentiful.

(4) Tentative predictions during the past few years have met with a good degree of success.

FRENCH INVESTIGATIONS IN THE NEWFOUNDLAND REGION FROM 1934 TO 1936

By Ed. le Danois, *Director of the Bureau of Maritime Fisheries*,

and

By Commanding Officer Beaugé, *in charge of the Research Vessel, the Président Théodore Tissier*

In 1934, the *Président Théodore Tissier*, an oceanographical vessel belonging to the Bureau of Maritime Fisheries, having crossed the Atlantic in proceeding along latitude 45° N., carried on research work in the Newfoundland banks region during September and October.

The hydrological results of the cruise have been set forth in a memorandum presented by Mr. le Danois in *Fasc. 2* of *Tome 9* of the *Revue des Travaux de l'Office des Pêches Maritimes*. Part of that memorandum is exclusively devoted to the hydrology of the banks.

The great cold wall lying east of the Newfoundland banks constitutes a permanent natural limit between the phenomena taking place in the Northern Atlantic and those which control the physicochemical conditions of the Newfoundland area.

The main data which have been set forth in the *Revue des Travaux de l'Office* may be summarized as follows:—

> The Labrador current, after crossing Davis strait, strikes the continental shelf formed by the island of Newfoundland and the banks. The Arctic waters stick to that shelf and, spreading over it, divide into manifold branches. Westward, the island of Newfoundland plays the part of a dike and two branches wind around it—one which, through the strait of Belle Isle, overruns the estuary of the St. Lawrence and, the other, which, forced to flow around the Avalon peninsula, reverts afterwards in a southwesterly direction to overspread the banks of Nova Scotia.
>
> The northern section of the Grand bank of Newfoundland has the effect of diverting eastward a third branch which soon divides itself into two unequal portions, the most important of which constitutes the massive sheet of the cold sheath, by extending as far as south of the Grand bank, while the other portion, which is of less importance, soon disappears after having touched ground on the isolated bank of "Flemish Cap".

At a depth of approximately 100 metres, the Arctic waters prevail almost everywhere within the pools lying between the banks and in the estuary of the gulf of St. Lawrence, (waters of a salinity of 32·5 to 33·0 ‰ and varying from 0° to −1°).

Coming from the south and acting under the influence of the Atlantic waters, the slope waters closely encircle the bottom waters with salinities varying around 34·0 ‰, and characterized by isotherm + 4°. However, there is not always a close relation between that isotherm and the slope waters, because it sometimes occurs that the bank waters undergo, in places, a warming up *in situ* and that isotherm + 4° extends far beyond the zone occupied by the waters of more than 33·0 ‰. This phenomenon is actually prevalent at the average depth of 50 metres, in the channel west of the Newfoundland bank. As pointed out several times by both myself and my collaborator, Captain Beaugé, this displacement of isotherm + 4° has an important effect upon the cod fishery.

Due to its proximity to the shoals, it often occurs that, near the edges, the + 4° waters are found below colder waters, in which case—and this is what happened in September, 1934—the fishermen have to search for fish on the slopes, underneath the cold waters of the mean layers.

The genuine Atlantic waters, above 35·0°/‰, never encroach, so to say, upon the Newfoundland banks, but, on the south and southeast, they closely embrace such banks and produce an effect on the slope waters. This action seems to be most effective at about longitude 55°, south of Green bank, where a lobe of the Gulf Stream is noticeable at a depth of approximately 100 metres. This fact seems to be responsible for the warming up of the waters of the bank in the western channel.

If reference is made to reports presented at various times, heretofore, with regard to the fishery fluctuations at Newfoundland, it will be noted that the years 1927-28 marked a period of variations in the fishing conditions. During the summer season, cod migrated from the southern banks to ascend in larger abundance than usual to the Labrador zone which resulted in what our fishermen call "a deficient season."

In making allowance for the relative transgressive maximum of 4½ years, the effect of which is to delay the normal thrust of the estival ascension of the Atlantic waters northward, it is at the end of nine years, in 1936 and 1937, that the same phenomenon should reappear with an action more or less noticeable.

On the other hand, the year of 1934, the last one perhaps, was favourable to the presence of cod in summer on the southern banks. The charts of temperature and salinity at 100 and 50 metres (Pages 184 and following, *Part II, Tome 9, Revue des Travaux*) indicate indeed that in September, that is to say, previous to the hibernal stabilization and perhaps at the time of the transgressive maximum, the bottoms, or grounds, are productive in several localities on the Newfoundland banks. The cyclonic arrows, especially those shown at 50 metres, are plainly

characteristic. A point from 4° to 6° at the Banquereau, southwest of the St. Pierre bank, in the channel between Green bank and Whale bank, towards the Platier (double point), corresponding to salinities of 33, or about, are extremely favourable.

That phenomenon was absolutely in keeping with the forecasts made by the bureau and the *Président Théodore Tissier* had an opportunity of confirming, by means of trawls, the presence of a considerable quantity of cod in the favourable areas, especially on the eastern edge of the Grand bank on bottoms of 300 to 400 metres (Fecamp trawl fishery); on the Grand bank, (latitudes 44° to 45° and longitudes 50° to 52°—Malo fishery), a point of Whale bank, (latitude 45° and longitude 55°—Tissier fishery); St. Pierre bank, (latitudes 45° and 46° and longitude 56°—Tissier fishery); Banquereau, (44° and 58° to 59°); Middle Ground on the Halifax coast, (Canadian and American fisheries).

In all the above areas, fish abound in the zone known by its fundamental characteristics as "cod water."

Furthermore, the researches carried on by the ship led her to discover a considerable abundance of cod of a very large size on the bottoms, or grounds, of the gulf of St. Lawrence, at a depth of 300 metres and more, in a region where fishing has never been carried on to date and where the temperature was favourable; whereas, along the "Treaty Shore," the fishing season had come to a close and fish were very scarce save, perhaps, in a few small areas along the coast which were being exhausted by the fishermen and from which cod could not come out, due to being surrounded by cold waters.

Year of 1935:—The *Ville d'Ys* carried on a hydrological profile which was run along latitude 46° north, between longitudes 45° and 55°. The situation is characterized by a thick layer of 3·5° to 4° between longitudes 45° and 47°, that is, east of the banks, at a depth of over 400 metres. On the contrary, on the banks, the cold water lies near the surface. The minimum of -1·5° is reached at a depth of 75 metres (longitudes 48° and 54°, that is to say, at the eastern and western edges). These are well-known features: Too thin a layer of polar waters, insufficiently fed by its source. The fishermen will be compelled to proceed northward in summer to find out favourable conditions.

These results have been confirmed by the fishermen: Fish abound at the edges during the spring and decrease in numbers until June, when they disappear almost entirely everywhere. In July, "white water" prevails from latitudes 44·30° to 45·00°, longitudes 50° to 51°.

Not until October, at the end of the month, and in November did cod return to the Platier of the Grand bank. Small haddock are then frequently found mixed with cod as soon as the mean waters are reached which are fairly warm (4·5° at 50 metres and 6° at 25 metres).

It follows that the fishermen were more successful this year at Greenland than they were during the previous years. The temperatures (Fylla and Store-Hekkefiske) are very favourable, (3° to 5°). Store-

Hekkefiske fish keep on the western edges; nearer to the mainland they rise to the surface. There is a lack of launce. Cod feeds particularly on worms which are abundant.

Year of 1936:—No investigations by the oceanographical ship in the region. The sources of information available are the soundings carried on by the *Ville d'Ys* and, also, the data supplied by the fishermen.

What had been foreseen is exactly what was encountered, viz.,—the return of the conditions of 1927. From a statement by Sir George Whiteley, I quote the following sentences,—

> "Captain Bob Bartlett, the well-known Arctic navigator, reported that during this past summer ice conditions in Davis, and Hudson straits and in Smith's sound were the lightest he had ever seen in all his years and Arctic explorations. Water temperatures in Melville bay were much higher than usual and practically no drift ice was encountered. Rather a remarkable year of mild summerlike conditions in the whole of the Canadian Arctic and Baffin bay."

That observation is absolutely in keeping with the information received from the fishermen, one of whom stated: "Not a single iceberg this year."

Consequently, fishing was highly favourable to the vessels which complied with the recommendations issued from the bureau. Captain Michelet, of the trawler *Mercedita*, broke all his previous records of fishing by portioning out his activities between the Grand bank of Newfoundland and Greenland. His results were tremendous, reaching a total of 35,000 hundredweights. The sail-boat *Zaspiakbat* on August 15th, reported a catch of 13,500 hundredweights, partly effected at Newfoundland and partly at Greenland.

A profile taken by the *Ville d'Ys* in the area lying between Newfoundland and Greenland is extremely characteristic. It has been run at a mean longitude of 52° between latitudes 51° and 67°. At 53° at 100 metres, warm water (over 3·5°) is encountered and the temperature is constant as far down as 400 metres. From 64° N., the course touches small grounds. The following features have been noted:—2·3° at a depth of 80 metres (latitude 64°); 1·7° at 90 metres (latitude 65°); 2° at 140 metres (latitude 66°); 4° at 30 metres (latitude 67°). Fish abound. One must get quite close to the Labrador coast to reach cold water.

The situation is a striking confirmation of the periodicity of the transgressive movement. It enables one to make very precise forecasts regarding the next fishing operations:

> Good spring fishing at Newfoundland; poor summer fishing. Excellent fishing at Greenland during the season. The greatest possibilities of a satisfactory summer, so far as the temperature and wind conditions are concerned.